

Arctic Oscillation and Polar Vortex Analysis and Forecasts

September 19, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Thursday.

For those who would like an early look on Tuesdays, we will be offering at a nominal price (US \$50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO) and Polar Vortex (PV). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather. During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

Subscribe to our email list or follow me on Twitter (@judah47) for notification of updates.

The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to remain neutral to negative the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to slowly turn mostly positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative with mostly positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to trend towards neutral the next two weeks as pressure/geopotential height anomalies will slowly become increasingly mixed across Greenland.
- Over the next two weeks, ridging/positive geopotential height anomalies across Greenland will help anchor troughing/negative geopotential height anomalies in the central North Atlantic further helping to anchor ridging/positive geopotential height anomalies across Europe with the exception of troughing/negative geopotential height anomalies in Western Europe this week only. This pattern will support normal to above to even well above normal temperatures across Europe the next two weeks including the United Kingdom (UK) but mostly next week. One exception is normal to below normal temperatures in Western Europe including the UK due to troughing this week.
- This week ridging/positive geopotential height anomalies are predicted to dominate Asia with the exceptions of troughing/negative geopotential height anomalies across Eastern Siberia and parts of Central Asia. Next week troughing/negative geopotential height anomalies will become focused across the Urals and Northern Siberia with ridging/positive geopotential height anomalies elsewhere across Asia but centered in East Asia. This pattern mostly favors normal to above normal temperatures widespread across Asia with normal to below normal temperatures across Eastern Siberia and parts of Central Asia this week and then normal to above normal temperatures again widespread across Asia with normal to below normal temperatures mostly limited to Northern Siberia.
- The general predicted pattern across North America the next two weeks is troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska and along the west coast of North America forcing ridging/positive geopotential height anomalies across eastern North America. This pattern generally favors normal to below normal temperatures for Alaska and the West Coasts of Canada and the United States (US) with normal to above normal temperatures widespread across most of Canada and the US east of the Rockies.
- In the Impacts section I continue to recap the Northern Hemisphere (NH) summer and pivot to next winter. As I like to describe below for now it is the red team vs. the blue team.

Plain Language Summary

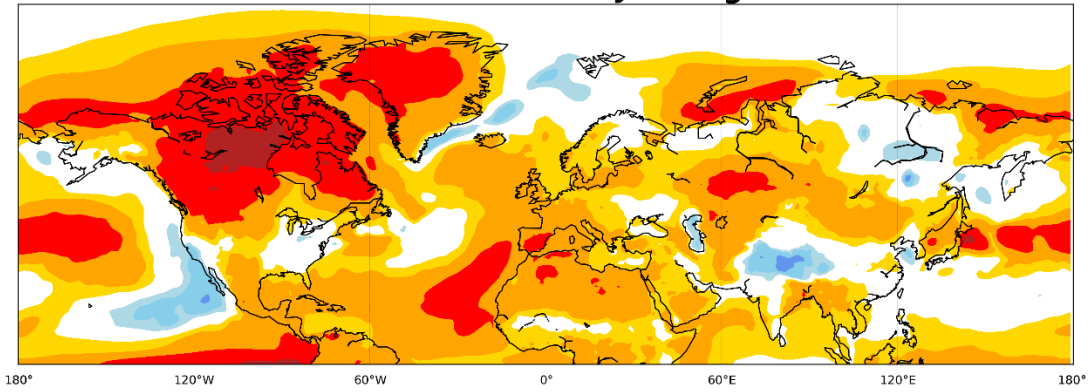
Despite the calendar reading fall, summer is hanging on tough with record heat in Europe and the US ongoing. some relief is on the way by next week especially in the Eastern US. And the string of summer extreme weather continues with record heat and flooding rainfall. The summer temperature pattern was overall consistent with forecasts

posted in the blog at the end of May (see **Figure iii**). Still too early to say much about this winter other than El Niño is a certainty. It is thought to favor an overall mild winter but not always.

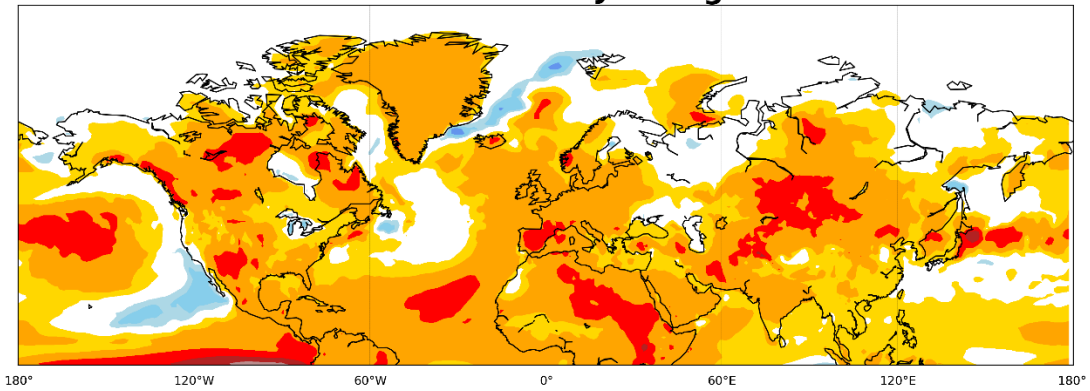
Impacts

This is the last time that I will discuss summer 2023. In **Figure i**, I show the two dynamical forecasts from the North American multi-Model Ensemble (NMME - top panel), the C3S ensembles (European multi model ensemble including ECMWF - second panel), the AER statistical model (third panel) and the observed surface temperature anomalies for June, July and August 2023 for the Northern Hemisphere (NH). The forecasts were posted in the [22 May 2023](#) blog. The observed temperatures are derived from NCEP/NCAR (NRR) reanalysis using a 30-year climatology of 1991-2020.

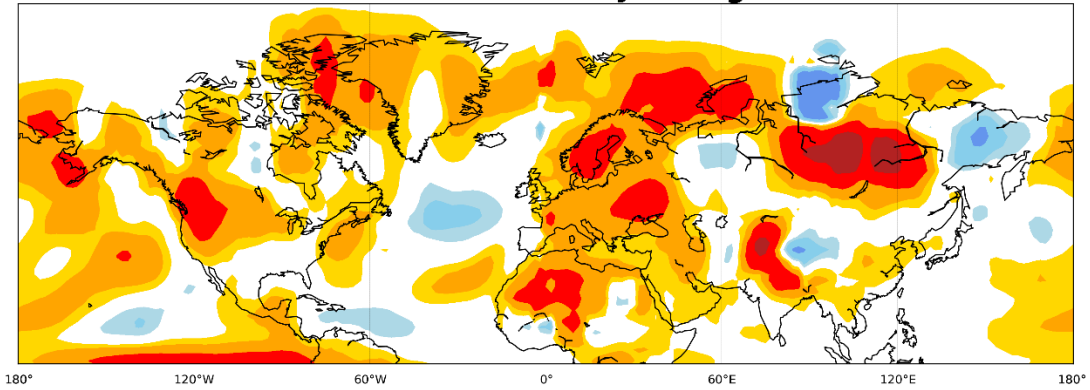
NMME Ts Forecast for Jun-Aug 2023



C3S Ts Forecast for Jun-Aug 2023



AER Forecast of Ts for Jun-Aug 2023



Observed Ts for Jun-Aug 2023

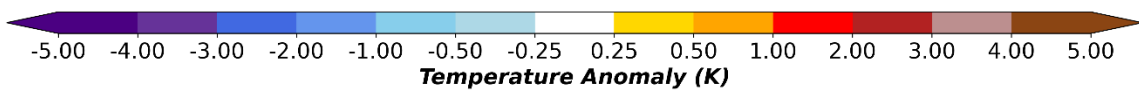
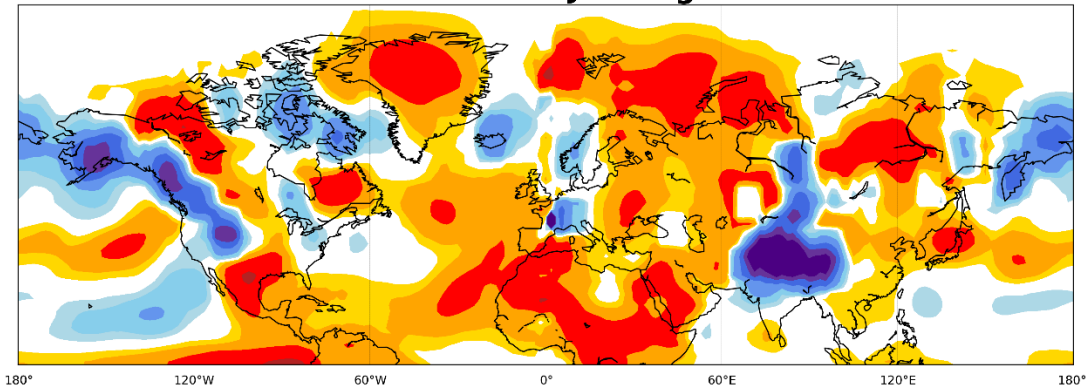


Figure i. The NMME surface temperature anomaly forecast for June, July, and August 2023 from <https://www.cpc.ncep.noaa.gov/products/NMME/> (top). The C3S surface temperature anomaly forecast for June, July and August 2023 from <https://www.copernicus.eu/en> (center). c) The AER surface temperature anomaly forecast for June, July, and August 2023 (third panel). d) Observed surface temperature anomalies for June, July and August 2023 from the NCEP/NCAR reanalysis (bottom).

I use the NNR reanalysis because that is what is used to generate the AER temperature forecast to be consistent, but it clearly has issues, the most obvious being too cold. I showed the observed temperatures from CFSR in last week's blog ([5 Sept 2023](#)) and in **Figure ii** I show the global plot from Copernicus, which is very similar to the CFSR plot. Above normal temperatures were almost universal most notably in western North America, Southern and Eastern Europe, the Middle East, North Africa and Central Asia (see **Figure iii**). Some regional exceptions were below normal temperatures in the Eastern US, Western Russia, parts of China and along the India-Pakistan border. I think that the AER model was very competitive with the dynamical forecasts systems, but all the models did a credible job, and each did better and worse in certain regions.

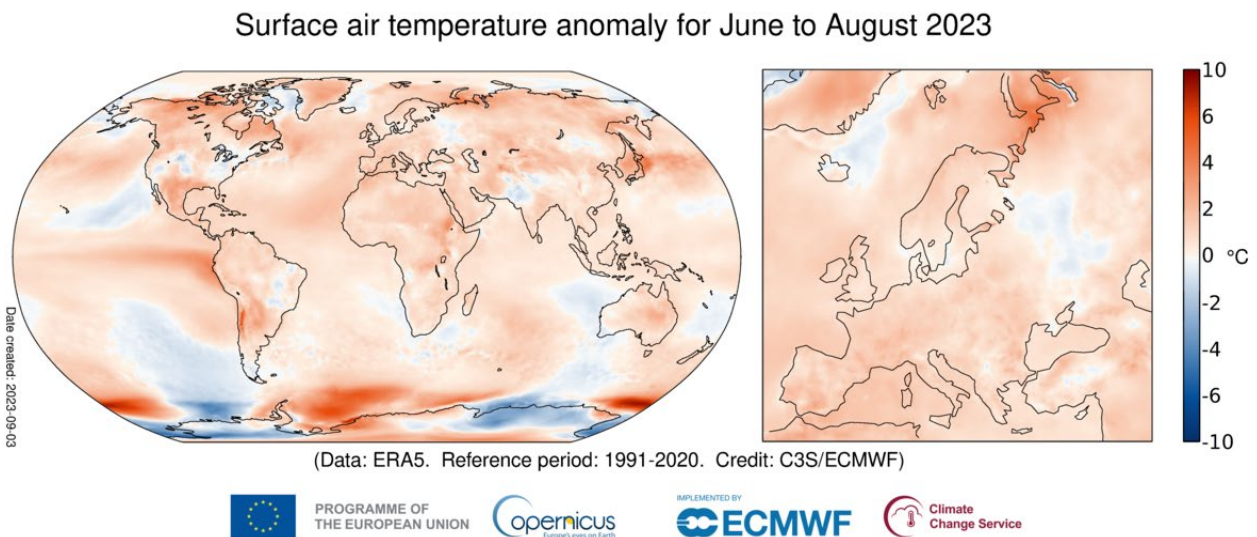


Figure iii. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) across the globe and Europe from 1 June – 31 August 2023 from the ERA5 and downloaded from <https://climate.copernicus.eu/surface-air-temperature-august-2023>

As we look ahead to October, summer or at least above to even well above normal temperatures are showing no signs of quitting or certainly leaving gracefully. We have several strong ridges spread across the NH, including Eastern Europe/Western Russia, East Asia but the most impressive by far is in Eastern Canada (see **Figures 5 and 8**). This will ensure above to even above normal temperatures for much of the NH including the US, Europe and large parts of Asia. In Eastern Canada I would expect record warmth and for sea ice formation in Hudson Bay to be significantly delayed.

You might think with heat domes centered over the continents and not over the Arctic Ocean this would favor preserving Arctic sea ice and even support the beginning of the sea ice growth season, but from NSIDC still no sign that the Arctic sea ice minimum has been reached. Looks like the minima will be close to the recent years of 2019 and 2020 and potentially in the top five lowest sea ice extents on record. Typically, the sea ice minima is observed in mid-September, therefore it appears to me to be a bit delayed.

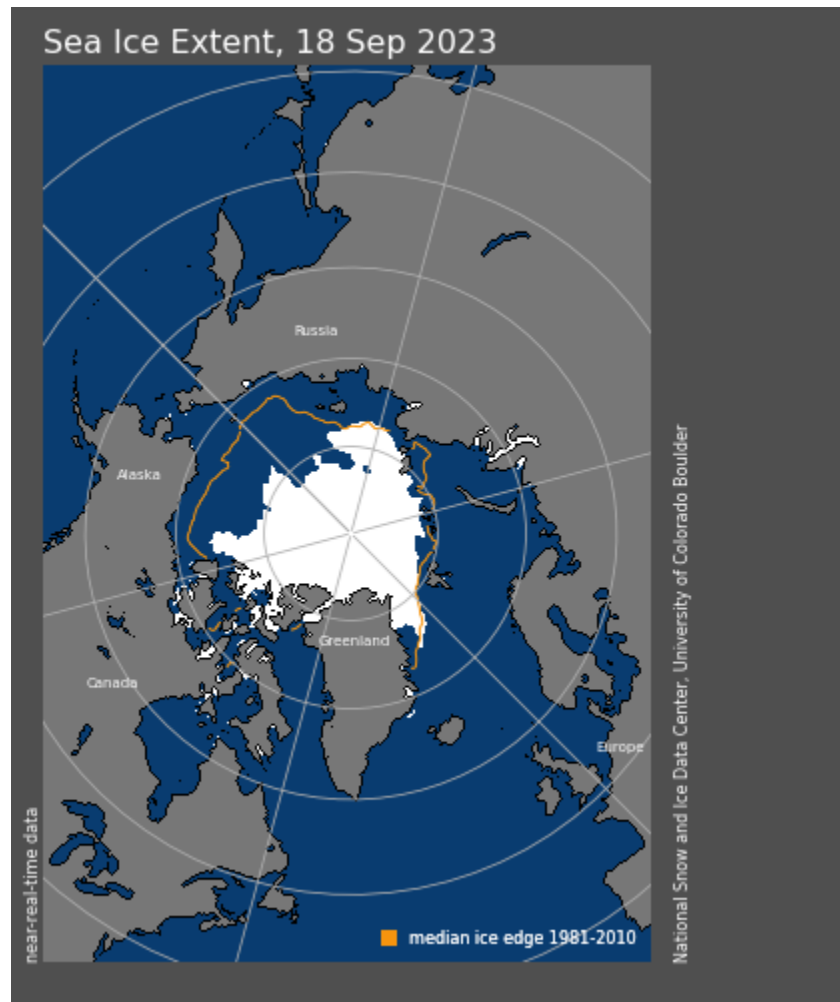


Figure iii. Observed Arctic sea ice extent on 18 September 2023 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC) <https://nsidc.org/arcticseaicenews/>

Looking at the current Arctic sea ice extent, it is almost completely shifted onto the North Atlantic side with the North Pacific side almost ice-free (see **Figure iii**). But overall low Arctic sea ice in the fall months favor a weaker polar vortex (PV) and cold temperatures in winter, at least regionally. However, research shows that it is sea ice absence only in the North Atlantic side favors a weak PV, but the extent can and will shift around. Though low sea ice on the North Pacific side is associated with a stronger PV it is also associated with colder temperatures in North America.

Like in the previous blog, if there is one feature that is giving me hope that a turn to fall and eventually winter weather are indeed coming, it's the predicted troughing (**Figure 8**) coupled with colder temperatures (**Figure 9**) and even snow for Siberia (see **Figure iv**). Snow cover extent is currently above normal for Siberia (not shown) but so far nothing impressive is apparent to me. And the predicted Siberian troughing and cold temperatures are not impressive. However, if the Ural blocking can become more amplified and persistent than predicted, then the outlook might look different. I argue that above normal snow cover in Siberia in the fall but especially October favors a weaker PV and a higher probability of severe winter weather across the NH continents.

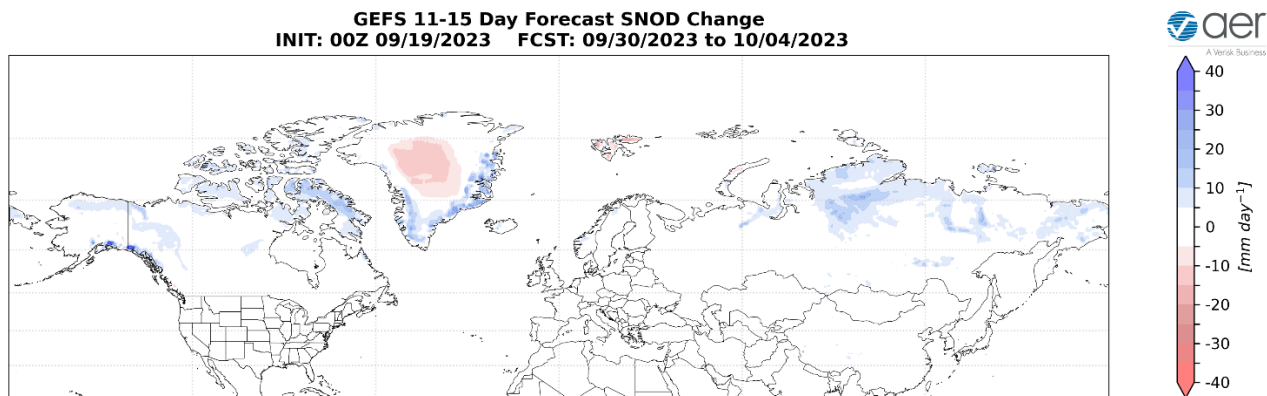


Figure iv. Forecasted snowfall rate (mm/day; shading) from 30 September – 4 October 2023. The forecast is from the 00Z 19 September 2023 GFS ensemble.

El Niño is all but certain for this winter and the one remaining question is how strong. A lot of the dynamical models are predicting a strong El Niño this winter. There are not that many historical data points for strong El Niño's but all have them have featured widespread mild temperatures. Many of the statistical models are predicting a moderate El Niño this winter and there have been more interesting winters during moderate El Niño. Also positive is the Indian Ocean Dipole (IOD). In late 2019 the IOD was strongly positive, and the winter of 2019/20 featured a record strong PV, record positive AO and very mild temperatures across the NH continents.

In summary the tropics (red team) are so far favoring a mild winter of 2023/24 but if the El Niño and positive IOD can remain more in the moderate range their influence could be moderated. Arctic boundary conditions (blue team) favor a weak PV and a colder winter, but it is very early and so far, the signals are weak. I think lots of uncertainty for now and how boundary conditions evolve this fall are critical.

Thursday Update

Not much new from Tuesday. The pattern across North America remains hostile to a robust transition from summer to fall and eventually winter. That ridge in Eastern Canada (see **Figure v**) remains tenacious with record warmth likely, the delay in ice

growth in Hudson Bay and retarding the advance of snow cover extent in eastern North America.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 09/21/2023 FCST: 10/02/2023 to 10/06/2023

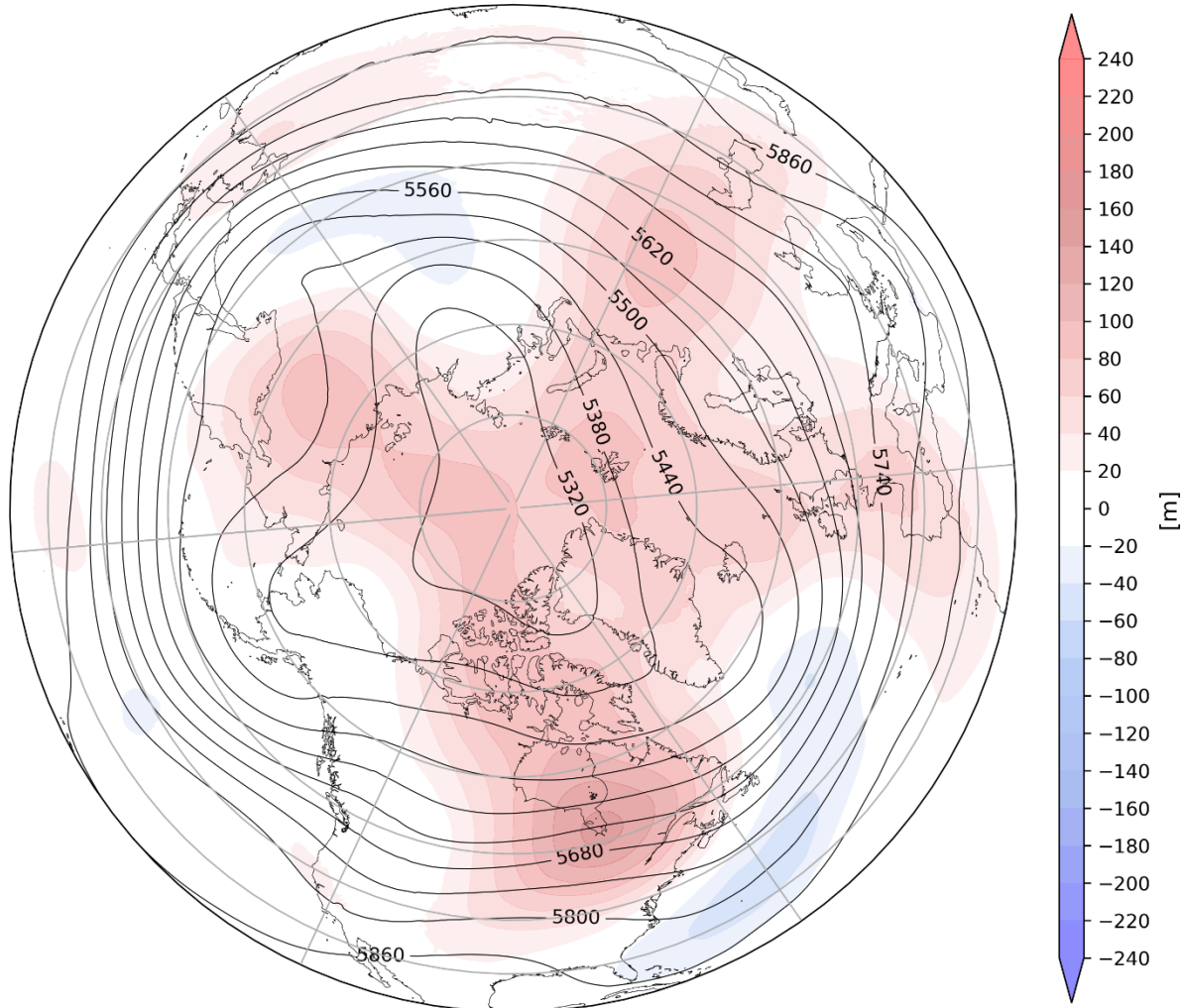


Figure v. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 2 – 6 October 2023. The forecasts are from the 00z 21 September 2023 GFS ensemble.

The only sign of a seasonal transition remains Siberia. A possibility that I discussed on Tuesday is becoming more likely, more amplified, and persistent ridging is predicted near the Urals coupled with higher geopotential heights in the Central Arctic (see **Figure v**). This should support cold temperatures at least for parts of Siberia and the continued advance of snow cover extent across the region (see **Figure vi**). Certainly not the perfect pattern for the establishment of cold and snow across Siberia given the

predicted ridging in Eastern Siberia but for winter weather enthusiasts that's the best we have right now with Canada stuck in reverse (summer).

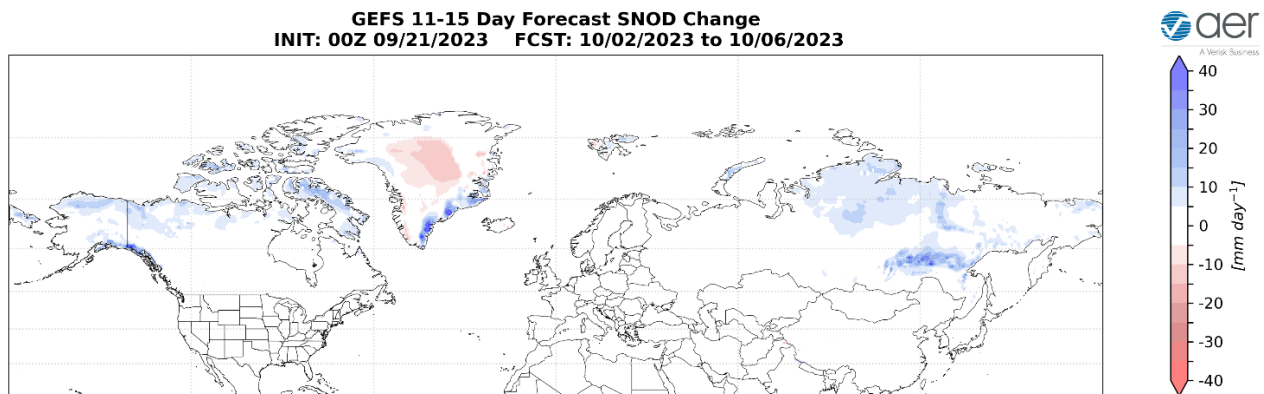


Figure vi. Forecasted snowfall rate (mm/day; shading) from 2 – 6 October 2023. The forecast is from the 00Z 21 September 2023 GFS ensemble.

I did forget to mention on Tuesday the quasi-biennial oscillation (QBO) is predicted to be easterly this winter, which should favor a weaker PV and colder temperatures across the NH continents. So though most would label it a tropical forcing, I will put the QBO on the blue team for now.

Near-Term

This week

The AO is predicted to be neutral this week (**Figure 1**) with mixed geopotential height anomalies across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With mostly positive geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to be negative this period.

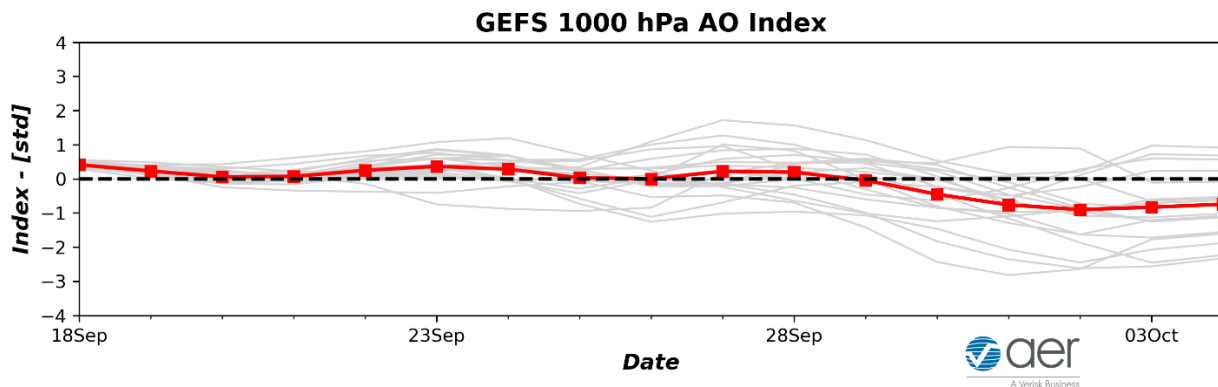


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 19 September 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies in the central North Atlantic that extends into Western Europe will force strong ridging/positive geopotential height anomalies across Eastern Europe (**Figures 2**). This pattern favors normal to above and well above normal temperatures across Central and Eastern Europe with normal to below normal temperatures across Western Europe including the UK (**Figure 3**). This week Asia is predicted to be dominated by ridging/positive geopotential height anomalies centered in Western Asia and Southwestern Siberia with troughing/negative geopotential height anomalies in Eastern Siberia and Central Asia centered over Kazakhstan (**Figure 2**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially Western Asia with normal to below normal temperatures limited to Eastern Siberia and parts of Central Asia (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 09/19/2023 FCST: 09/20/2023 to 09/24/2023

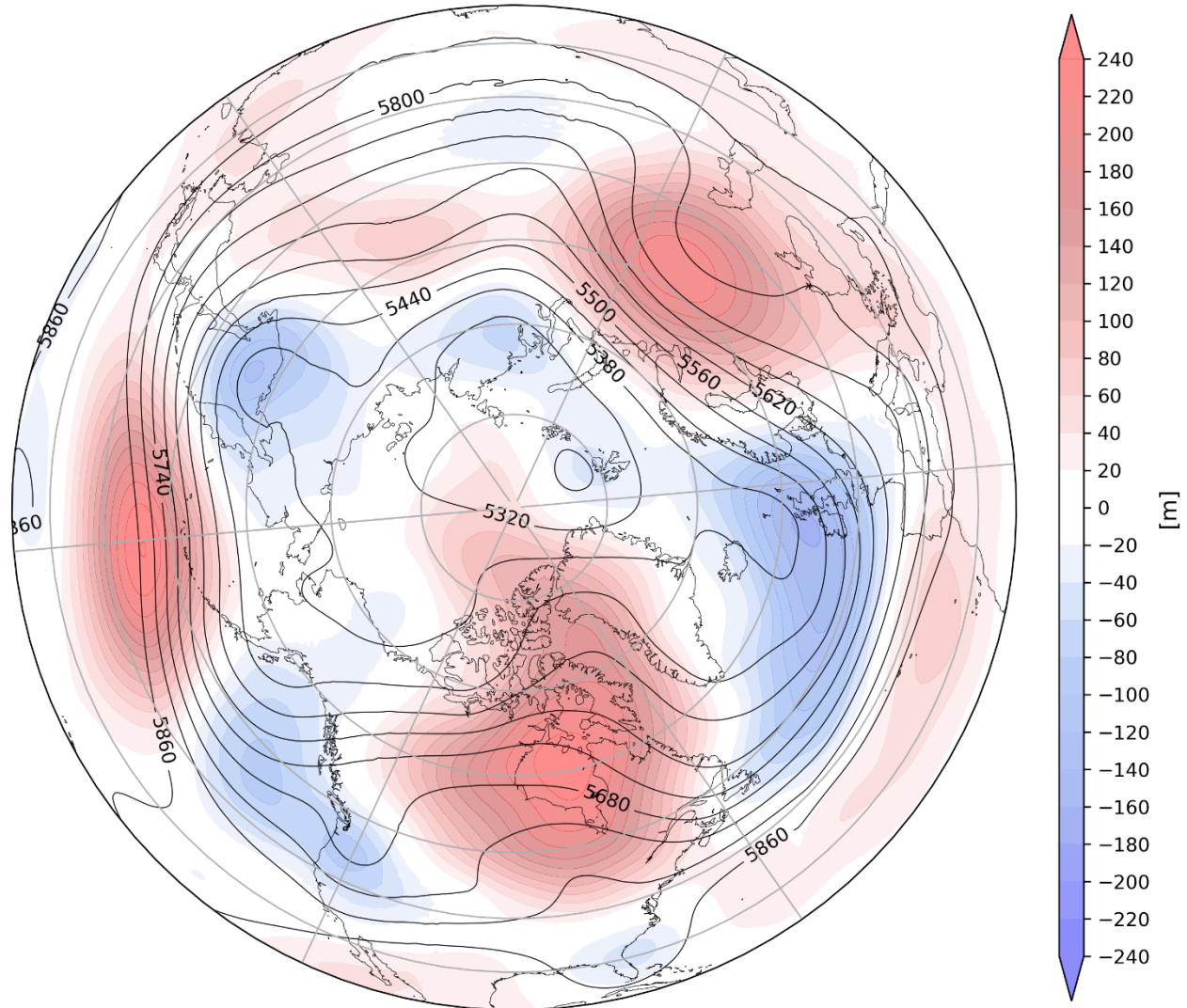


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 20 – 24 September 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

The pattern this week across North America is troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska and along the west coast of North America forcing ridging/positive geopotential height anomalies across much of eastern North America with weak troughing/negative geopotential height anomalies in the Southeastern US (**Figure 2**). This pattern will favor widespread normal to above normal temperatures across much of Canada and the US east of the Rockies with normal to below normal temperatures across Alaska, the West Coasts of Canada and the Southeastern US (**Figure 3**).

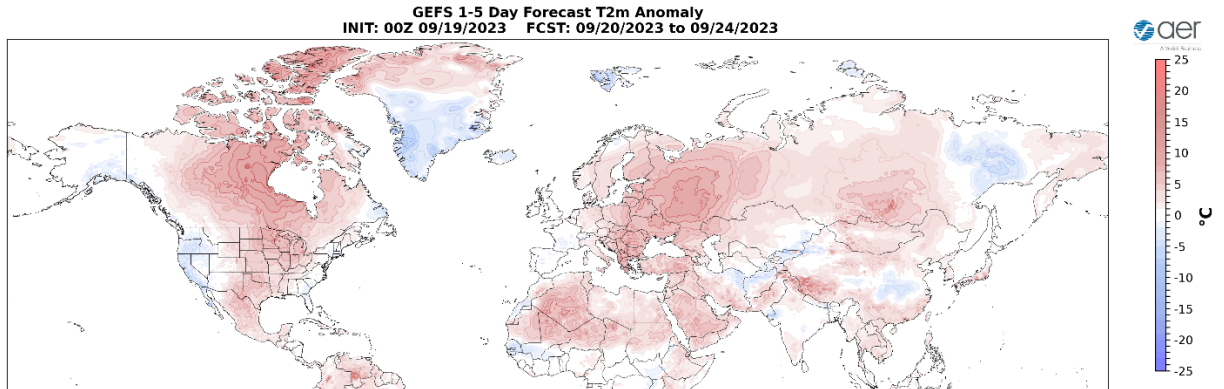


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 20 – 24 September 2023. The forecast is from the 00Z 19 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Northern Europe, the Alps, the Balkans, Eastern Siberia, Southern China and central India this week (**Figure 4**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across Southeastern Alaska, the Central US and along the US East Coast (**Figure 4**).

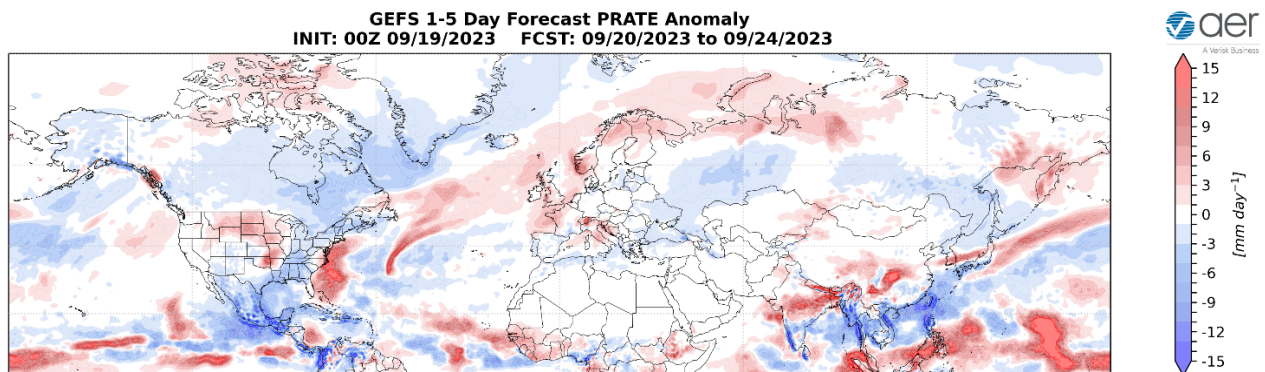


Figure 4. Forecasted precipitation rate (mm/day; shading) from 20 – 24 September 2023. The forecast is from the 00Z 19 September 2023 GFS ensemble.

Near-Mid Term

Next week

With mixed geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should remain close to neutral this period (**Figure 1**). With predicted weak but slightly positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be neutral to negative this period.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 09/19/2023 FCST: 09/25/2023 to 09/29/2023

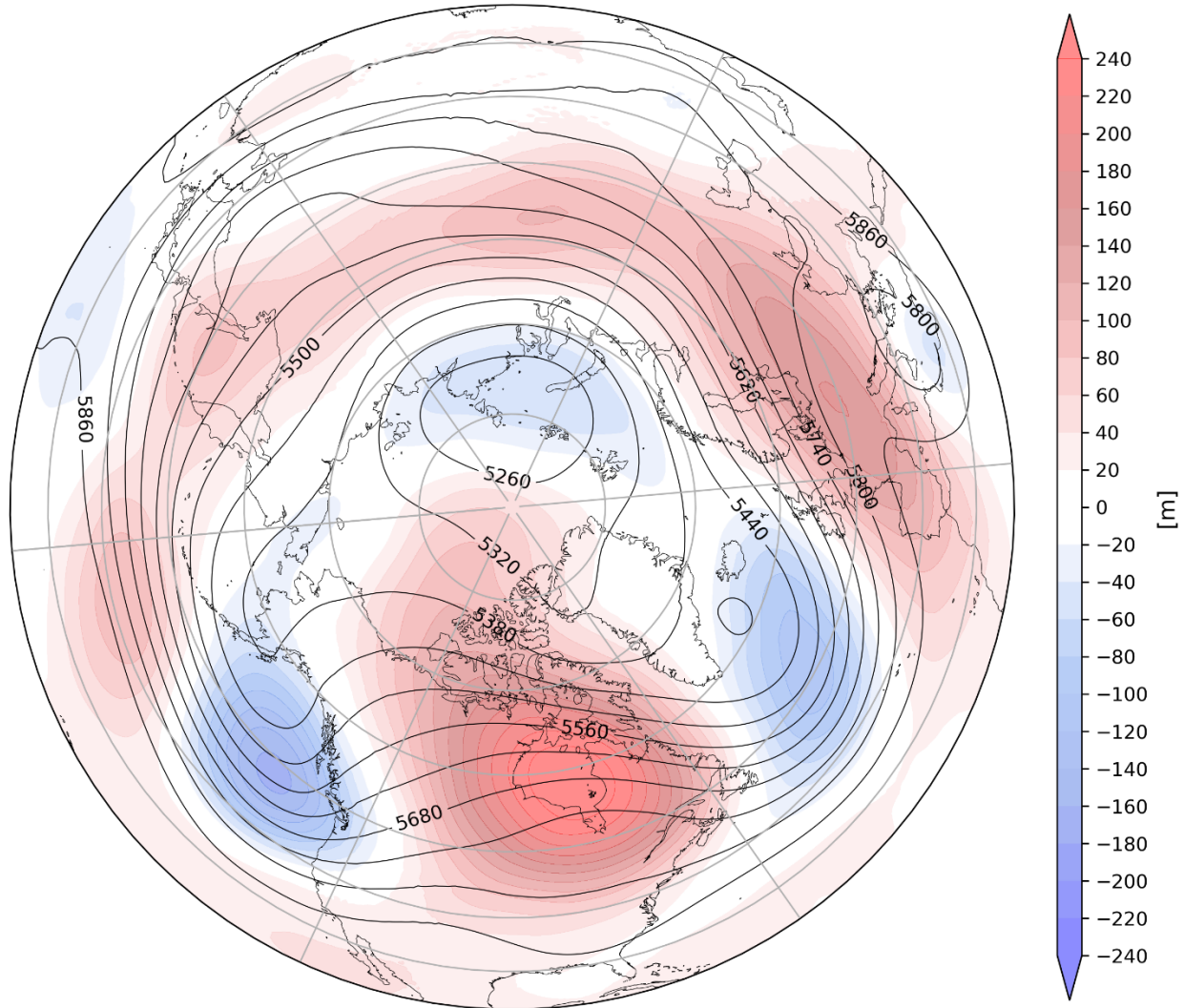


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 25 – 29 September 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies in the central North Atlantic will continue to support ridging/positive geopotential height anomalies across Europe this period (**Figure 5**). This pattern should favor normal to above and even well above normal temperatures across Europe including the UK (**Figures 6**). The general pattern across Asia is predicted ridging/positive geopotential height anomalies across the mid-latitudes of Asia with regional troughing/negative geopotential height anomalies persisting in Eastern Siberia and parts of Central and East Asia this period (**Figure 5**). The pattern favors normal to above normal temperatures across most of

Asia with normal to below normal temperatures limited to parts of Central Asia, Mongolia, and Eastern Siberia this period (**Figure 6**).

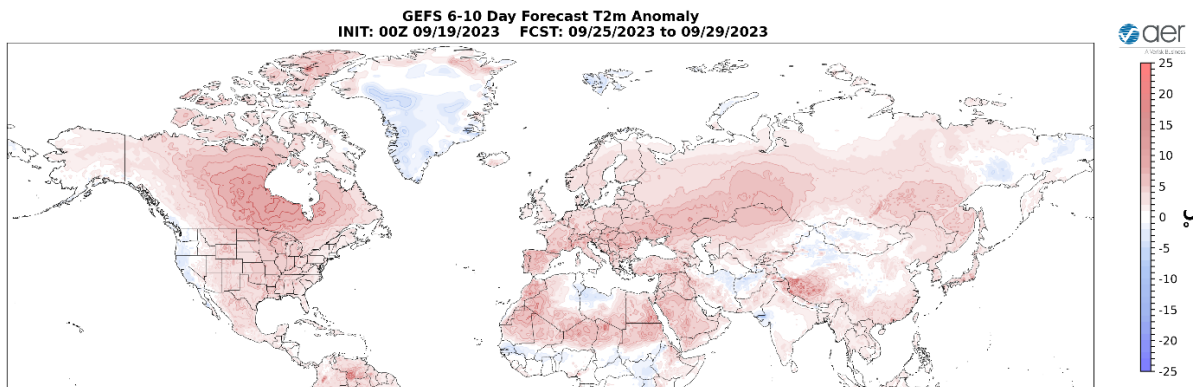


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 25 – 29 September 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

The predicted general pattern across North America this period is persistent troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska and the west coast of North America forcing ridging/positive geopotential height anomalies across much of Canada and the US east of the Rockies (**Figure 5**). This pattern favors normal to above normal temperatures across much of Canada and the US east of the Rockies with normal to below normal temperatures limited to the coastal regions of Alaska, Western Canada and the Western US (**Figure 6**).

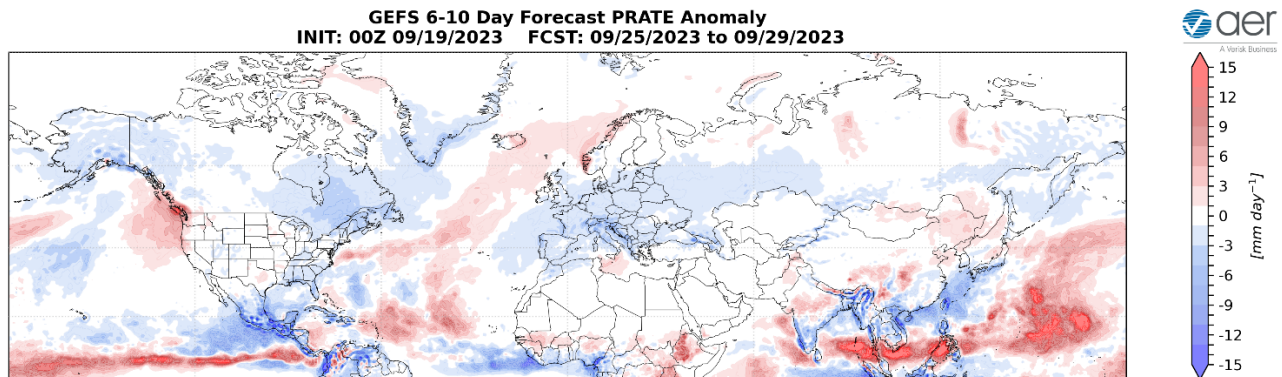


Figure 7. Forecasted precipitation rate (mm/day; shading) from 25 – 29 September 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Norway, Eastern Siberia, Southern China and central India this period (**Figure 7**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across

Southeastern Alaska, the Canadian West Coast and the US Pacific Northwest (Figure 7).

Mid Term

Week Two

With predicted mostly positive geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (Figure 8), the AO should turn negative this period (Figure 1). With predicted mixed and weak pressure/geopotential height anomalies across Greenland (Figure 8), the NAO will likely approach neutral this period.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 09/19/2023 FCST: 09/30/2023 to 10/04/2023

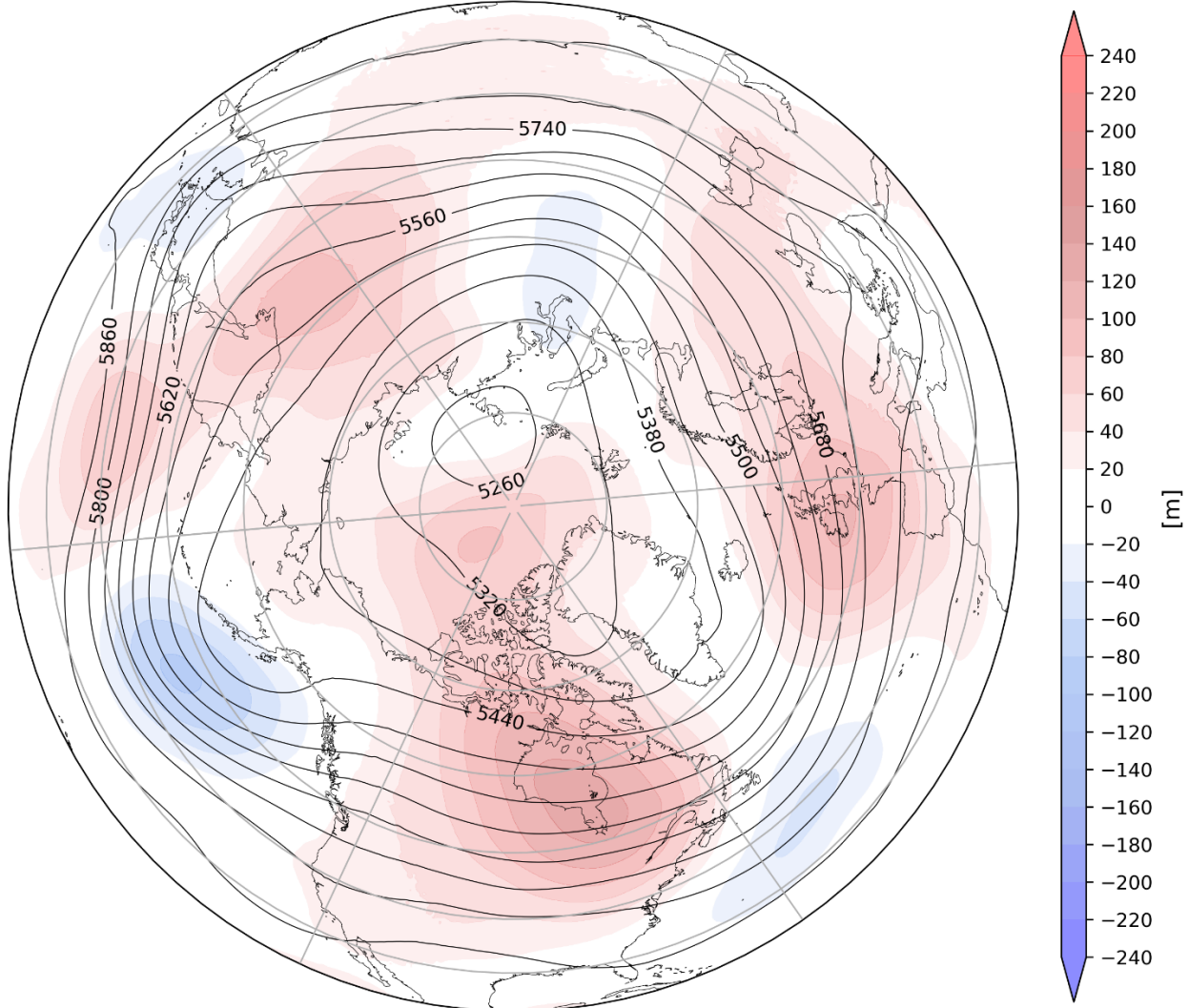


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 30 September – 4 October 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies across the central North Atlantic will anchor ridging/positive geopotential height anomalies across Europe this period (**Figure 8**). This pattern should favor normal to above normal temperatures across much of Europe including the UK this period (**Figures 9**). Widespread ridging/positive geopotential height anomalies are predicted across Asia but centered in East Asia with troughing/negative geopotential height anomalies mostly limited across the Urals and far Northern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures mostly limited to Northern Siberia this period (**Figure 9**).

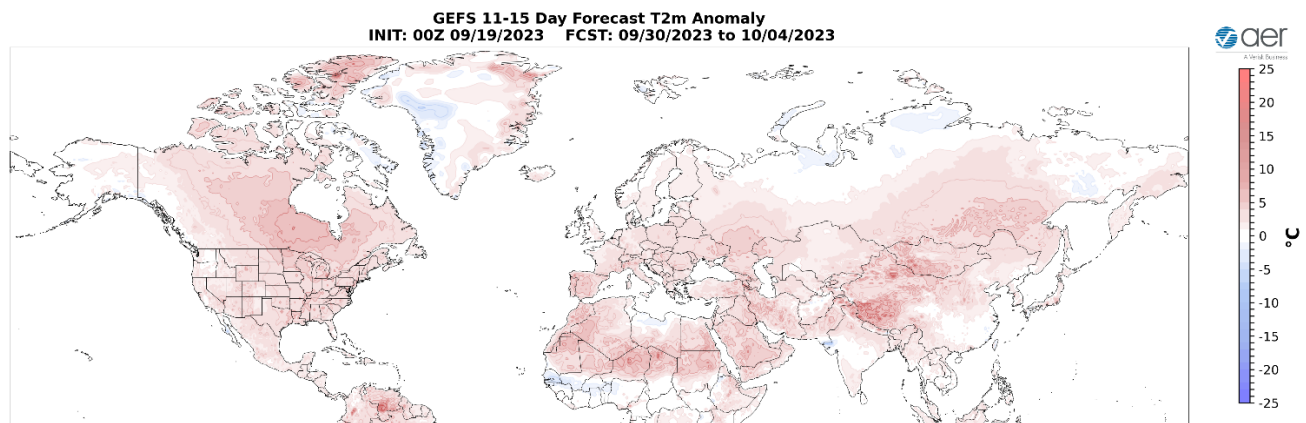


Figure 9. Forecasted surface temperature anomalies (°C; shading) from 30 September – 4 October 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to persist in the Gulf of Alaska forcing ridging/positive geopotential height anomalies across much of North America this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, most of Canada and much of the US with normal to below normal temperatures mostly limited to pockets in Alaska and the West Coasts of Canada and the US (**Figure 9**).

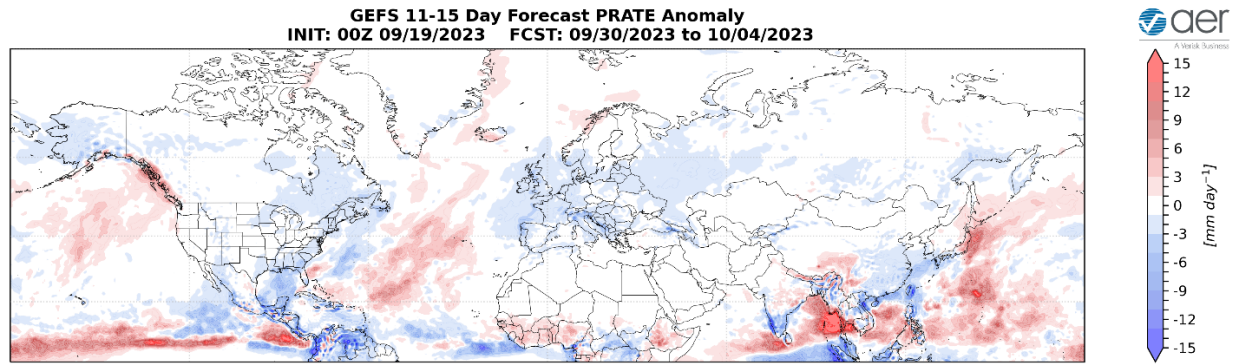


Figure 10. Forecasted precipitation rate (mm/day; shading) from 30 September – 4 October 2023. The forecasts are from the 00z 19 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across the Tibetan Plateau and Japan this period (**Figure 10**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across Southeastern Alaska and the West Coast of Canada (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs in the mid to upper stratosphere and lower troposphere with warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). Next week warm/positive PCHs in the upper troposphere are predicted to descend into the lower troposphere (**Figure 11**).

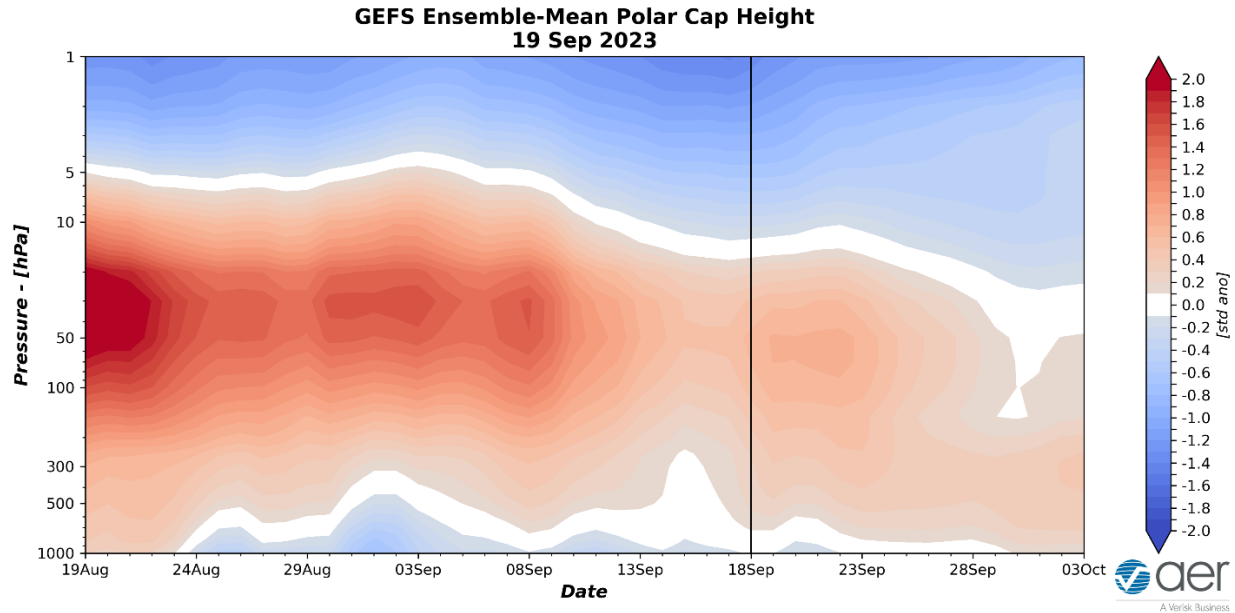


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 19 September 2023 GFS ensemble.

The predicted cold/negative but weak PCHs in the lower troposphere this week (**Figure 11**) are consistent with the predicted neutral surface AO this week (**Figure 1**). However, the AO is predicted to become more biased negative next week (**Figure 1**) coinciding with the predicted warming PCHs in the lower troposphere (**Figure 11**).

CFS 500 hPa Forecast Anomaly Oct 2023
Valid as of 19 Sep 2023

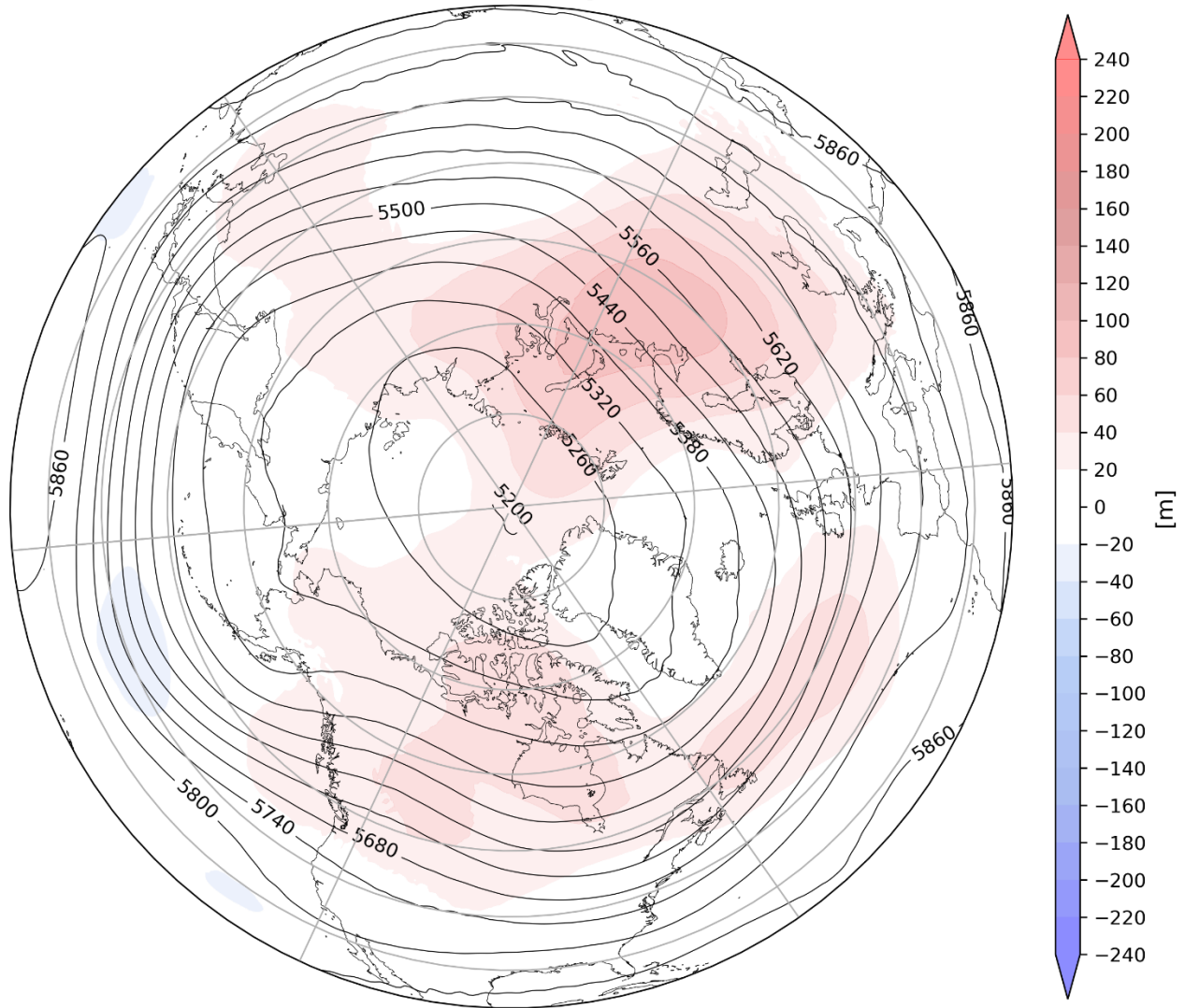


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2023. The forecasts are from the 00Z 19 September 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for October (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered near Iceland and Greenland, Western Siberia, Alaska and Western Canada with troughing across Western Asia and Eastern Europe centered on the Urals, and across much of North America but centered in Canada (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Eastern Europe, Northern and Southern Asia, Alaska, Canada and the much of the US with

seasonable to relatively cool temperatures across parts of Western Europe, Central and Eastern Asia (**Figure 13**).

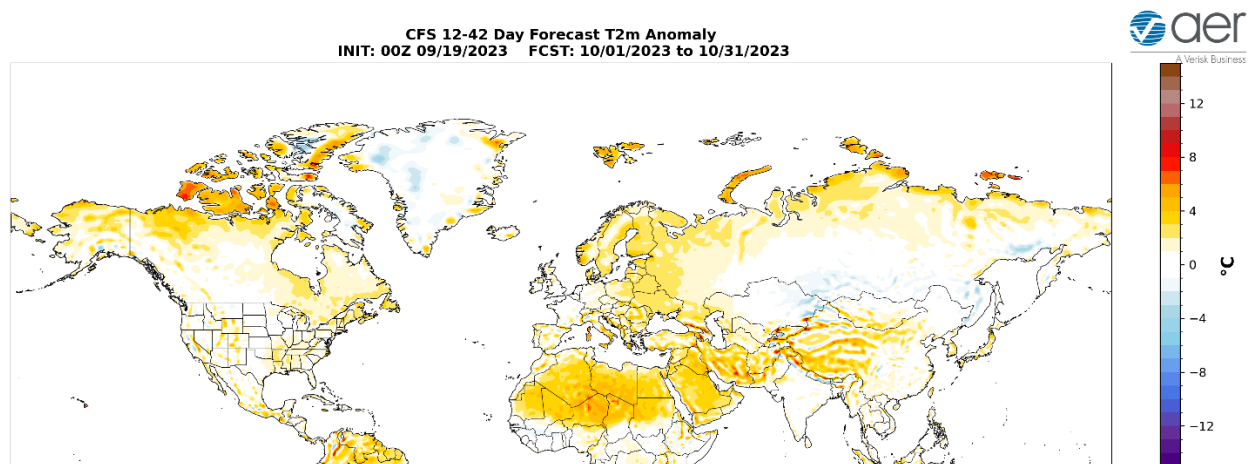


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2023. The forecasts are from the 00Z 19 September 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are above normal, especially along the South America coast, indicating that the transition from La Niña to El Niño is complete (**Figure 14**) and El Niño conditions are expected through the fall. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific, the eastern North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

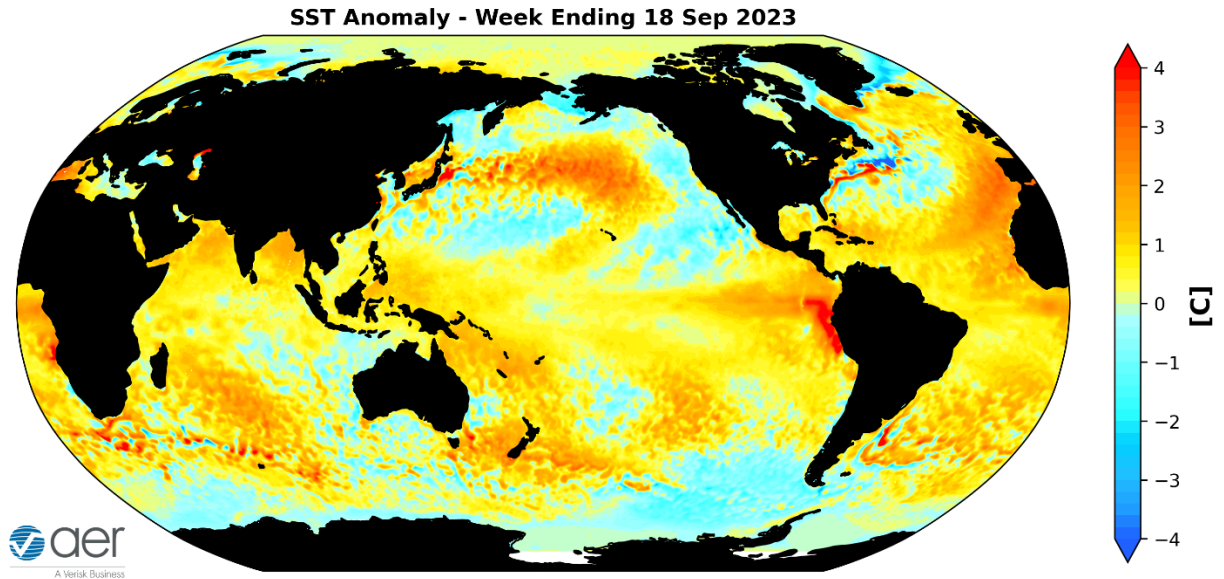


Figure 14. The latest weekly-mean global SST anomalies (ending 18 September 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is weak where no phase is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored over the next two weeks. Seems that the MJO is having little influence on the weather across North America in the short term. But admittedly this is outside of my expertise.

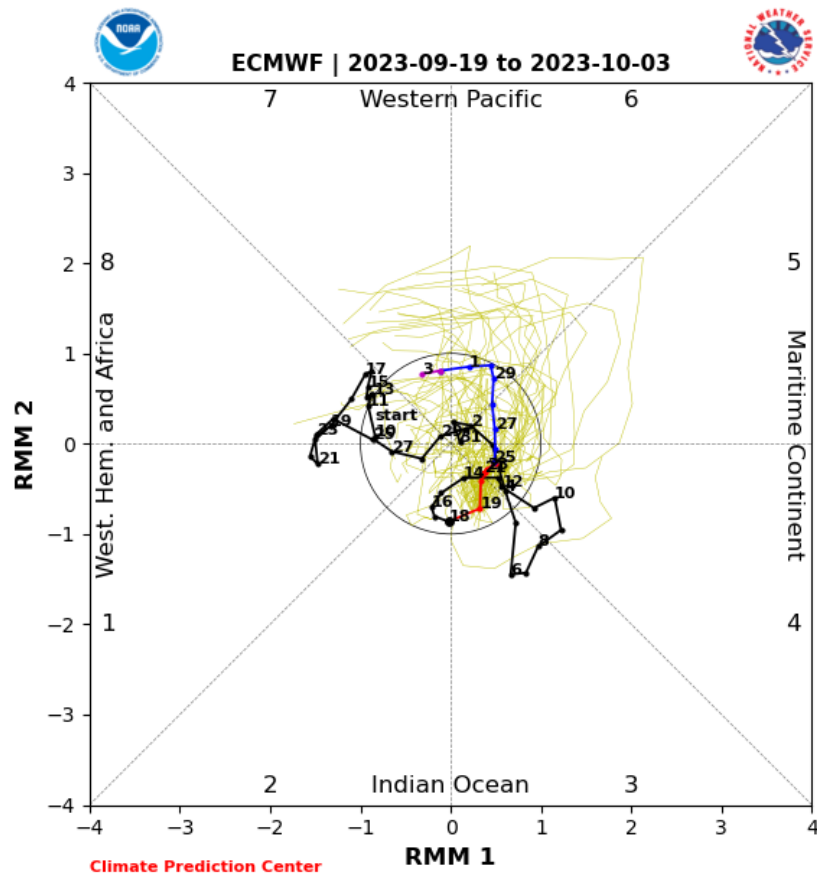


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 19 September 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source:

https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml

Get Detailed Seasonal Weather Intelligence with sCast

We appreciate your taking the time to read the public Arctic Oscillation blog from Dr. Judah Cohen and the AER Seasonal Forecasting team.

Dr. Cohen’s detailed monthly seasonal forecast, sCast, is also available for purchase. sCast provides a monthly 30-60-90-180-day outlook into temperature and precipitation, solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

Our sCast principal engineer, Karl Pfeiffer, can help you use sCast and other AER seasonal forecast products to deliver important, long-lead time weather intelligence to your business. Please reach out to Karl today!